A STUDY OF THE FOOD HABITS OF SIX ANURAN TADPOLES[1]

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(With two text-figures)

The intestinal contents of tadpoles of six anuran species, collected from different waterbodies, were studied to find out their food in natural habitat. The gut contents revealed that all the tadpoles studied were largely herbivorous and ingested 36 genera of algae. The food is apparently determined by the nature of the habitat. It seems that in nature the tadpoles studied fed randomly, without any discrimination. The existing literature indicates that these tadpoles have the capacity to adjust their feeding habits to available food in new environments.

INTRODUCTION

All adult amphibians are carnivorous and devour whatever they can overcome, such as crustacea, small fishes, worms and insects. Tadpoles, on the other hand, are largely herbivorous (Cunningham 1912). They are fundamentally specialised for suspension feeding (Wassersug 1975) and depend mainly on algae for their food in natural habitats. The laboratory food for tadpoles as suggested by McCann (1932) was raw meat and also aquatic plants like *Hydrilla, Ceratophyllum, Lemna* and *Vallisneria.*

The dietary habits of tadpoles have been studied by Kamat (1962), Sabnis and Kolhatkar (1977), Sabnis and Kuthe (1980) and Wassersug *et al.* (1981). Sabnis and Kuthe examined the natural food of tadpoles of *Bufo melanostictus* by gut analysis. Wassersug *et al.* described the tadpoles of *Philautus* sp. in Thailand as macrophagus, feeding on frog eggs. Literature on natural food of tadpoles is meagre, whereas there is fairly adequate information on the diet of adult frogs (Andrews 1979, Davidson 1916, Isaac and Rege 1975, Joshee 1968, Mohanty-Hejmadi and Acharya 1982, Rangaswamy and Channabasavanna 1972).

The present study examines the dietary components of tadpoles of *Bufo melanostictus* (Family Bufonidae), *Ramanella montana* (Microhylidae), *Rana tigerina, Rana limnocharis, Tomopterna breviceps* (Ranidae) and *Polypedates maculatus* (Rhacophoridae) in nature.

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MATERIAL AND METHODS

Tadpoles were collected from various waterbodies like pools, river, cisterns and ponds in Sanjay Gandhi National Park in Borivli, Bombay (18° 55'N, 72° 54'E) during the monsoon of 1983. The tadpoles were collected with a net and preserved in 10% formalin. In the laboratory they were sorted out into pre-hindlimb and hindlimb stages.

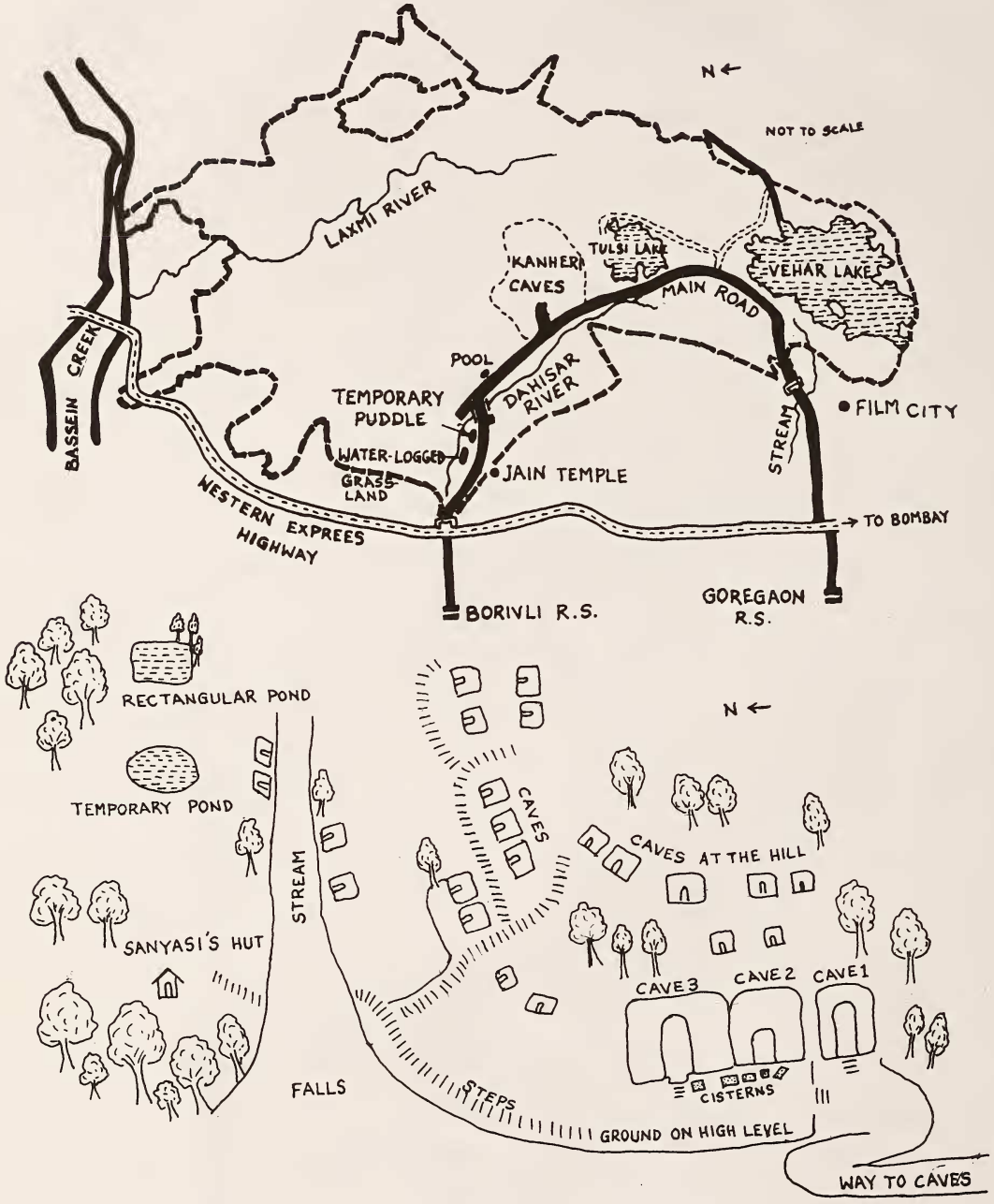
To study the gut content, the intestine was removed, squashed in a small petri-dish and liquefied by adding 5 ml of water. The fragments of empty intestine were removed and the liquid gut content was analysed under a 320 x microscope. The algal materials were identified and counted in viewing area of 0.732 sq. mm. Five similar squares were counted for algal components, and the average taken. Ten tadpoles per stage were examined.

Tadpoles of different species were collected from the following waterbodies (Figs. 1, 2).

(1) *Bufo melanostictus*: Dahisar river and a small stream near Film City. (2) *Ramanella montana*: Dahisar river and roadside pool. (3) *Rana tigerina*: Pond near Jain temple and rectangular pond at Kanheri Hill. (4) *Rana limnocharis*: Temporary puddle and water-logged grassland. (5) *Tomopterna breviceps*: Dahisar river and corridor of Kanheri cave No.1 with 5 cm depth of still water. (6) *Polypedates maculatus*: Pool near Sanyasi's hut and temporary puddle.

RESULTS AND DISCUSSION

The data on food items in the gut of six tadpole species are shown in Tables 1-6. All six



Figs. 1-2. Location of collection sites of tadpoles at Sanjay Gandhi National Park and Kanheri Caves.

TABLE 1
PERCENTAGE OF FOOD ITEMS IN THE GUT OF TADPOLES OF *Bufo melanostictus*

Intestinal contents	Dahisar river		Stream near Film City	
	Pre-hindlimb stage	Hindlimb stage	Pre -hindlimb stage	Hindlimb stage
Oscillatoria	1.06	6.19	9.73	2.26
Scenedesmus	–	–	–	0.75
Phacus	0.30	–	0.54	–
Oedogonium	0.04	–	–	–
Closterium	0.23	–	–	–
Cosmarium	3.26	1.03	–	–
Pinnularia	74.17	63.92	74.05	47.10
Navicula	17.73	21.65	12.97	13.85
Cymbella	2.35	2.06	1.08	–
Synedra	0.76	3.09	–	32.49
Stauroneis	–	–	–	3.02
Euchalanis	–	–	1.08	–
Nematode worm	–	2.06	0.54	0.25

TABLE 2
PERCENTAGE OF FOOD ITEMS IN THE GUT OF TADPOLES OF *Ramanella montana*

Intestinal contents	Dahisar river		Roadside pool	
	Pre-hindlimb stage	Hindlimb stage	Pre-hindlimb stage	Hindlimb stage
Oscillatoria	0.21	0.33	–	–
Spaerella	–	–	–	15.62
Oedogonium	–	–	9.37	–
Cosmarium	0.85	1.76	–	–
Vaucheria	–	–	3.13	6.25
Pinnularia	98.50	97.23	56.25	43.75
Navicula	0.43	0.66	12.50	12.50
Spores	–	–	18.75	18.75
Daphnia	–	–	–	3.15

tadpoles were largely herbivorous; 36 genera of algae and four species of animalcules were recorded from the stomach contents. The intestines were long and spirally coiled like a watch-spring. Noble (1931) stated that the more carnivorous tadpoles have a shorter digestive tract than herbivorous species.

Wassersug (1975) reported that the unique morphology of tadpoles is in some way associated with herbivory, plankton feeding, filter feeding, suspension feeding etc. The elongated, coiled intestines of most tadpoles contrast sharply with the shortened digestive tract of the few known carnivorous, non-feeding, or direct developing forms.

Food items of tadpoles collected from running water differed from those collected from still water. For example the food of *Bufo melanostictus* tadpoles collected from Dahisar river as well as from the stream near Film City gate varied and certain food items like *Eudorina, Opalina, Spirogyra, Ulothrix, Euglena*, watermites and

TABLE 3
PERCENTAGE OF FOOD ITEMS IN THE GUT OF TADPOLES OF *Rana tigerina*

Intestinal contents	Pond near Jain temple		Rectangular pond at Kanheri Hills	
	Pre-hindlimb stage	Hindlimb stage	Pre-hindlimb stage	Hindlimb stage
Oscillatoria	7.48	1.51	0.04	0.14
Spirulina	–	–	1.56	0.38
Scytonema	–	–	0.09	0.13
Eudorina	–	7.09	1.95	1.78
Pediastrum	2.04	3.92	–	–
Ankistrodesmus	–	5.13	–	–
Selenastrum	–	–	11.64	12.94
Tetraedron	–	2.57	0.58	1.95
Scenedesmus	34.69	12.08	77.83	81.09
Ulothrix	–	–	0.24	0.23
Phacus	2.72	28.70	0.44	0.51
Oedogonium	0.68	0.90	0.14	0.10
Closterium	–	3.63	–	–
Euastrum	–	0.15	–	–
Cosmarium	–	–	0.04	0.10
Pinnularia	26.53	22.96	0.29	0.31
Navicula	3.40	0.75	0.44	0.23
Spores	21.76	8.00	4.45	0.38
Monostyla	–	–	–	0.07
Nematode worm	0.68	2.26	–	–
Daphnia	–	0.15	0.19	–
Tardigrada	–	0.15	–	–

Pleurococcus were absent. However, Sabnis and Kuthe (1980) have reported these food items in *B. melanostictus* collected from a pond.

Similarly, tadpoles of *Tomopterna breviceps* obtained from Dahisar river had eaten only a few varieties of food items, whereas tadpoles of the same species collected from still water in the corridor of Kanheri Cave 1 had consumed more food items. The food is apparently determined by the nature of the habitat. Running water, generally, contains less microfauna than ponds and puddles. Tonapi (1980) also noted the conspicuous absence of many rooted plants and the relative absence of plankton in running water. But tadpoles of *Ramanella montana* had fed on a limited number of food items though they were collected from stagnant water (rain pool). This might be due to the nature of the pool (fresh and muddy water, with meagre algal components).

The food items differed for different locations, even for the same species of tadpole. *Oedogonium, Closterium* and *Cosmarium* were found in *Bufo melanostictus* tadpoles of Dahisar river but not in tadpoles from the stream near Film City. In *Rana tigerina* tadpoles, *Scenedesmus* was noticed both from the pond near Jain temple and the rectangular pond at Kanheri caves. However, there were several differences in food items from *tigerina* tadpoles from these two locations – *Spirulina, Scytonema, Selenastrum, Ulothrix, Cosmarium* and *Monostyla* were found in Kanheri caves tadpoles, but not in Jain temple tadpoles. There are similar location-related differences in the case of other species also.

From this data it seems that tadpoles feed randomly without any discrimination, on whatever is available in the particular waterbody where they grow up. Costa and Balasubramanium

TABLE 4
PERCENTAGE OF FOOD ITEMS IN THE GUT OF TADPOLES OF *Rana limnocharis*

Intestinal contents	Temporary puddle		Waterlogged grassland	
	Pre hindlimb stage	Hindlimb stage	Pre hindlimb stage	Hindlimb stage
Oscillatoria	0.93	2.38	0.26	1.00
Spirulina	–	–	0.52	0.25
Lyngbya	1.85	1.70	3.65	3.72
Anabaena	0.93	0.68	–	–
Scytonema	–	–	0.52	0.50
Tolypothrix	1.39	1.36	–	–
Sphaerella	2.78	3.40	1.30	1.49
Oocystis	–	–	3.65	3.22
Ankistrodesmus	–	–	0.52	0.25
Scenedesmus	4.17	0.34	–	–
Oedogonium	5.55	4.08	1.04	1.00
Phacus	2.31	1.20	–	–
Zygnema	–	–	0.26	0.25
Closterium	11.11	8.84	3.65	4.96
Pleurotaneum	–	–	2.08	1.00
Euastrum	1.38	1.70	5.73	5.46
Microsterias	–	–	1.30	0.25
Cosmarium	26.85	15.99	13.54	18.11
Staurastrum	3.70	2.38	2.60	3.47
Onychonema	–	0.34	9.11	7.20
Desmidium	–	0.34	3.13	6.20
Pinnularia	24.07	41.84	33.59	30.52
Navicula	12.04	10.20	7.55	6.70
Cymbella	0.93	2.72	5.20	3.72
Synedra	–	0.68	–	–
Monostyla	–	–	0.52	0.25
Daphnia	–	–	0.26	0.25

(1965) showed from stomach content analyses that *Rhacophorus cruciger* larvae are qualitatively non-discriminant in the food that they ingest. Similar analyses for *Rana clamitans* tadpoles showed that these larvae are qualitatively and quantitatively non-discriminant in their suspension feeding (Farlowe 1928). But, controversially, Kamat (1962) reported that tadpoles did not feed on all available algae. He found in the laboratory that tadpoles did not feed on certain algae like *Chara, Cladophora, Pithophora*. However, more work is required to prove that tadpoles show food preferences in natural environment.

Some diatoms (*Pinnularia, Navicula, Scenedesmus, Closterium, Cosmarium*) which are suspended in the water, were found in the present study to have been fed on in good percentage. Presumably, these were abundant in that particular period and were therefore taken by the tadpoles. Wassersug (op. cit.) stated that tadpoles are highly specialised suspension feeders, adapted for utilizing rapid increases in primary production of a food source. Such sources are probably coupled to environmental fluctuations and available for only a limited amount of time during any year.

TABLE 5
PERCENTAGE OF FOOD ITEMS IN THE GUT OF TADPOLES OF *Tomopterna breviceps*

Intestinal contents	Dahisar river		Corridor of Cave 1 at Kanheri	
	Pre-hindlimb stage	Hindlimb stage	Pre-hindlimb stage	Hindlimb stage
Gloeocapsa	0.63	–	1.70	5.65
Oscillatoria	21.65	19.59	19.57	17.39
Spirulina	–	–	6.80	1.74
Lyngbya	–	–	2.55	0.87
Scytonema	–	–	25.95	15.21
Oedogonium	1.91	0.50	5.95	1.74
Phacus	–	–	0.85	1.30
Closterium	–	–	–	0.43
Cosmarium	–	–	4.25	1.74
Spirogyra	2.54	2.51	–	–
Pinnularia	22.29	32.16	8.08	8.69
Navicula	37.57	32.66	3.40	8.69
Cymbella	–	–	1.70	1.30
Synedra	12.10	11.05	–	1.74
Spores	–	–	17.87	32.17
Nematode worms	1.70	1.50	0.43	1.30
Tardigrada	–	–	0.85	–

McCann (1932) suggested raw meat as a food for tadpoles reared in the laboratory. Sekar (1990) fed tadpoles of the Malabar gliding frog *Rhacophorus malabaricus* with earthworms, meat and snail flesh in the laboratory to rear them. These non-algal food items were readily accepted.

Wassersug *et al.* (1981) reported that the larvae of *Theloderma stellatum* (Rhacophoridae) of Thailand, which developed in tree holes containing decomposing leaves, fed on amoeba tests, fungal spores, lepidopteran scales etc.

In contrast, tadpoles of *Philautus* sp., which developed in a tree hole containing less than 75 ml of water without any indirect source of food, appear to rely on introduced frog eggs for food. It seems that tadpoles might have the capacity to adapt to a new environment and adjust to feeding on the food available in that environment.

There was notably no difference between the pre-hindlimb and hindlimb stages; food items were similar in both stages.

CONCLUSIONS

Gut analysis of six species of tadpoles led to the following conclusions.

(1) All the tadpoles studied were largely herbivorous in food habits; a variety of algal components constituted the major food items. (2) Tadpoles from still water fed on more food items than those obtained from running water. (3) In nature, the tadpoles studied fed randomly, without any qualitative discrimination. (4) Tadpoles which are fundamentally specialised for suspension feeding fed more on diatoms like *Pinnularia, Navicula, Cosmarium* etc. (5) Food items were almost similar in both pre-hind limb and hindlimb stages.

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TABLE 6
PERCENTAGE OF FOOD ITEMS IN THE GUTS OF TADPOLES OF *Polypedates maculatus*

Intestinal contents	Pool near Sanyasi's hut		Temporary puddle	
	Pre-hindlimb stage	Hindlimb stage	Pre-hindlimb stage	Hindlimb stage
Gloeocapsa	–	–	1.01	–
Oscillatoria	4.79	6.61	2.53	0.39
Lyngbya	–	–	1.01	0.39
Sphaerella	2.17	3.78	4.04	1.76
Ankistrodesmus	0.09	–	–	–
Scenedesmus	3.44	3.78	7.07	5.69
Ulothrix	–	–	0.25	0.19
Oedogonium	16.00	17.12	2.77	0.76
Phacus	7.78	6.85	0.76	0.19
Spirogyra	–	–	2.70	1.96
Closterium	2.44	1.18	–	–
Pleurotaenium	–	–	0.25	–
Euastrum	–	–	1.26	0.98
Microsterias	–	–	0.76	–
Cosmarium	23.32	12.87	20.96	26.93
Staurastrum	2.99	2.72	1.76	2.95
Pinnularia	8.41	6.14	28.03	18.86
Navicula	14.92	10.86	6.31	18.23
Cymbella	–	–	3.03	2.16
Synedra	–	–	8.33	2.16
Calonies	–	–	4.55	13.75
Spores	13.38	27.74	–	–
Monostyla	0.27	–	0.76	0.98
Nematode worms	–	–	0.25	0.19
Daphnia	–	0.35	–	–
Unidentified	–	–	1.76	0.58

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